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Georgia Tech Research Corporation
505 Tenth Street NW

Atlanta, GA 30332 -0420

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The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

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UU	UU	UU	UU		19b. TELEPHONE NUMBER 404-385-8652

RPPR Final Report
as of 26-Nov-2018

Agency Code:

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INVESTIGATOR(S):

Name: Baratunde A. Cola
Email: cola@gatech.edu
Phone Number: 4043858652
Principal: Y

Organization: **Georgia Tech Research Corporation**
Address: 505 Tenth Street NW, Atlanta, GA 303320420
Country: USA
DUNS Number: 097394084 EIN: 580603146

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Final Report for Period Beginning 07-Apr-2016 and Ending 06-Apr-2017
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Begin Performance Period: 07-Apr-2016 **End Performance Period:** 06-Apr-2017
Report Term: 0-Other

Submitted By: Baratunde Cola Email: cola@gatech.edu
Phone: (404) 385-8652

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STEM Degrees: **STEM Participants:**

Major Goals: This DURIP acquisition has been placed in the Nanomaterials Floor of the Marcus Nanotechnology Building at Georgia Tech, where 3 faculty, over 30 graduate students, and more than 5 post docs, research engineers, and visiting scholars are co-located for dedicated and collaborative research spanning 4 departments: Mechanical Engineering, Materials Science and Engineering, Electrical and Computer Engineering, and Chemical and Biomolecular Engineering. The tool is available to all of these researchers, and to the more than 300 users of the facilities of the Marcus Nanotechnology Building for research and educational activities. The Marcus Nanotechnology Building is a part of the Georgia Tech Institute for Electronics and Nanotechnology (IEN).
This DURIP has helped to advance carbon nanotube rectenna development, fundamental understanding of thermal and electrical transport in conjugated polymers, and launch a new area of thermoplasmonic energy conversion in nanowires.
The acquisition of our resistive thermal evaporator has been central for the research described above. A key factor in our ability to accomplish the research goals is an ability to produce reliable, controlled devices at a steady rate for the scientific studies. The acquisition of the deposition tool proposed here allows this, overcoming current rate limiting challenges at Georgia Tech. Our tool is the only at Georgia Tech that allows deposition of low work function metal for our devices without a very low yield and/or the ability to test and preserve the samples in an inert atmosphere.

Accomplishments: We purchased an Angstrom Engineering NexDep Deposition System with Integrated Glove Box that we custom designed to deliver on the goals of this DURIP. Resistive evaporation is a commonly used vacuum deposition process in which electrical energy is used to heat a filament which in turn heats a deposition material to the point of evaporation. The process can be performed at very high levels of vacuum allowing for a long mean free path and therefore fewer tendencies to introduce film impurities. High deposition rates can be achieved and lower energy particles can reduce substrate damage. Angstrom Engineering developed a thin film deposition systems based on this technique that can deposit a wide range of materials including metals, organic, and inorganic polymers. The process is controlled using quartz rate sensor, temperature, or optical monitoring systems to ensure consistent high-quality results.
We integrated a controlled atmosphere glove box to overcome our current physical vapor deposition (PVD) process challenges. This total system integration allows non-PVD and PVD processes to be connected within a controlled environment. The integrated system allows sensitive materials and substrates to be stored, then moved from process to process and tested without exposure to the open environment. This equipment is integrated with a substrate temperature controller for improved grain boundary migration, post process annealing and controlling surface reactions.

Important features of our NexDep system include:
- Support for multiple PVD processes
- Recipe based advanced multi-layer deposition control with user logon control
- Sequential or co-deposition
- Sensors are rigidly mounted to ensure calibration is maintained
- In co-deposition configurations QCM sensors are carefully isolated to ensure there is no interference from adjacent source material
- Stainless steel isolation shields help to protect sources from cross contamination
- Substrate heating and cooling
- Planetary motion
- Custom chamber height of 48 inches, which is required to minimize the interfacial degradation

After the tool was installed, several projects advanced as a result of these new capabilities and we were able to make new rectenna devices with record efficiencies of more than 10X higher than previous efforts.

Training Opportunities: Several Ph.D. students were able to use our new evaporator to advance their work. One Ph.D. student, Erik Anderson, has become an expert with the tool and gain skills in helping others with their projects.

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: Graduate Student (research assistant)
Participant: Erik Anderson
Person Months Worked: 3.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

Nothing additional to report